4. VACUUM SYSTEM

The RHIC vacuum system is divided into four regions: 1) the cold-bore UHV system, housed within the magnet bores and at the interconnects of the superconducting magnets; 2) the standard warm-bore systems residing between Q3-Q4 insertion regions; 3) the cryostat vacuum systems, serving as the insulating vacuum for the superconducting magnets, and 4) the experimental warm-bore regions, having their own unique vacuum materials and pressure requirements.

i. Beam Vacuum

The RHIC machine, must store two counter-rotating particle beams for periods of greater than ten hours. RHIC beams may comprise protons, gold ions (i.e., Au^{+79}), or a wide variety of heavy ions, colliding with each other. The intensity and emittance, and thus usefulness, of the particle beams are diminished when the stored particles are lost from their contrived orbits either due to charge exchange processes or through nuclear and Coulomb scattering with residual gas molecules. Equally important, particle beam collisions with residual gas in regions near the experimental detectors cause background noise in these detectors, and are therefore undesirable. For these reasons, a low operating pressure in the RHIC is very important. The RHIC rings, illustrated in Fig. 4-1, comprise two separate 3.8 km circumference rings. About sixteen percent of the life of each beam is spent in *warm*, RT (i.e., room temperature) sections of the rings; the remainder is spent in beam pipes operating at ~4.5 K (i.e., the *cold-bore*). An average pressure of 5×10^{-10} Torr ($2x10^{+7}$ molecules/cm^3) or less is required in the warm sections, with residual gases comprising 90% H_2, 5% CO and 5% CH_4. The pressure specification for beam components not baked in-situ such as kickers, septum and rf cavities is $\leq 2\times10^{-9}$ Torr, in the same gas species proportions as above. The requirement for the average total pressure of the cold-bore is $\leq10^{-11}$ Torr ($2x10^{+7}$ molecules/cm^3 after correcting for thermal transpiration) comprising exclusively H_2 and He. At this vacuum level, the emittance growth of a gold beam, at $\gamma = 10$, due to elastic scattering in the warm sections, will be $\sim 1\times10^{-4}$ mm mrad per hour, and $\sim 2\times10^{-4}$ mm mrad per hour in the cold-bore sections.

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[1] M. J. Rhoades-Brown, M. Harrison, *Vacuum Requirements for RHIC*, Informal Report AD\RHIC-106,BNL #47070 December 1991.

The beam lifetimes due to central nuclear collisions of the gold beam with gas, is ~ 600 hours in the warm sections and ~ 240 hours in the cold sections.

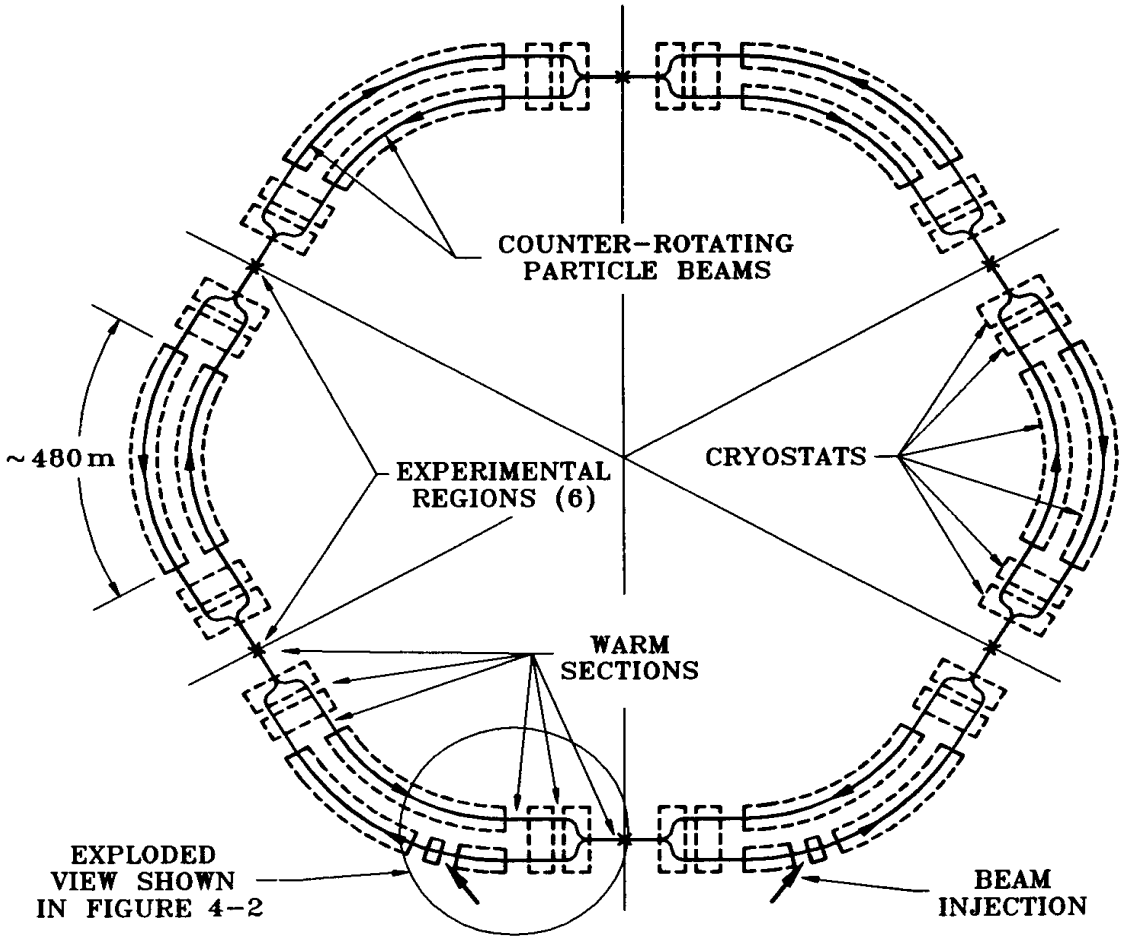

Fig. 4-1. The layout of RHIC vacuum systems.